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STUDY OF INELASTIC BEHAVIOR OF FLAT SLAB BUILDINGS UNDER SEISMIC LOADING

[1]Mirza Bashar Nawaz Baig, [2]L. G. Kalurkar

[1]Master of Engineering Student, [2]Associate Professor
[1,2]Civil Engineering Department
[1,2]Jawaharlal Nehru Engineering College, Aurangabad - 431005, INDIA

Abstract: Flat slabs are increasingly favored due to their economic advantages over traditional beam-column connections. However, many existing flat slabs lack seismic design, necessitating studies of their seismic response and retrofit strategies. Performance-Based Seismic Engineering offers a modern approach to earthquake-resistant design, extending limit state principles to address the complex challenges faced by structural engineers. This paper presents findings from a pushover analysis of flat slabs using ETABS software. A G+7 frame with 5 bays was analyzed, revealing that flat slabs exhibit a higher performance point compared to conventional buildings.

***Index Terms*:** *Flat slab, Pushover analysis, Capacity demand curve, ETABS*

I. INTRODUCTION

Recent earthquakes, causing severe damage or collapse of concrete structures, highlight the need for assessing the seismic adequacy of existing buildings, particularly in regions where 60% of the land is prone to significant seismic hazards. While earthquakes cannot be prevented, preparedness and adherence to safe building practices can mitigate damage and loss. Static pushover analysis has become a popular method for evaluating the seismic performance of both existing and new structures. This paper utilizes ETABS software to perform pushover analysis on flat slabs, which are increasingly favored for their economic advantages over beam-column connections, despite often lacking seismic design.

Pushover analysis involves incremental static analysis to generate a building's capacity curve, from which the target displacement indicative of the building's response to design level earthquakes is determined. The resulting damage assessment informs decisions on retrofitting or rehabilitating specific structural components. An established method for nonlinear static pushover includes the capacity spectrum method (CSM) and the displacement coefficient method (DCM), with various researchers contributing refinements. Accurate pushover analysis depends on the ability of analytical models to capture the inelastic behavior and plastic yielding effects of reinforced concrete structures under seismic loads.

II. SYSTEM DEVELOPMENT

Pushover Methodology: A pushover analysis is performed by subjecting a structure to a monotonically increasing pattern of lateral loads, representing the inertial forces which would be experienced by the structure when subjected to ground shaking. Under incrementally increasing loads various structural elements may yield sequentially. Consequently, at each event, the structure experiences a loss in stiffness. Using a pushover analysis, a characteristic non linear force displacement relationship can be determined. A generalized force-displacement characteristic of a non-degrading frame element (hinge Properties) is shown in Figure 1.

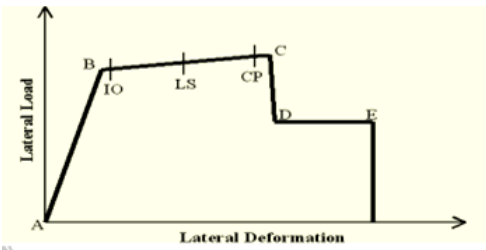

Figure 1: Load –Deformation curve

Point A corresponds to unloaded condition and point B represents yielding of the element. The ordinate at C corresponds to nominal strength and abscissa at C corresponds to the deformation at which significant strength degradation begins. The drop from C to D represents the initial failure of the element and resistance to lateral loads beyond point C is usually unreliable. The residual resistance from D to E allows the frame elements to sustain gravity loads. Beyond point E, the maximum deformation capacity, gravity load can no longer be sustained.

Capacity: The overall capacity of a structure depends on the strength and deformation capacities of the individual components of the structure. A Pushover analysis procedure uses a series of sequential elastic analysis, superimposed to approximate a force – displacement capacity diagram of the overall structure. The mathematical model of the structure is modified to account for reduced resistance of yielding components. A lateral force distribution is again applied until a predetermined limit is reached. Pushover capacity curves approximate how structure behaves after exceeding the elastic limits.

Demand (Displacement): Ground motions during an earthquake produce complex horizontal displacement patterns in structure that may vary with time. Tracking this motion at every time step to determine structural design requirements is judged impractical. For nonlinear method it is easier and more direct to use a set of lateral displacement as a design condition for a given structure and ground motion, the displacement is an estimate of the maximum expected response of the building during ground motion.

Performance Point: The intersection of the capacity spectrum with the appropriate demand spectrum in the capacity spectrum method (the displacement at the performance point is equivalent to the target displacement in the coefficient method). Typical seismic demand Vs. Capacity is shown in following figures.

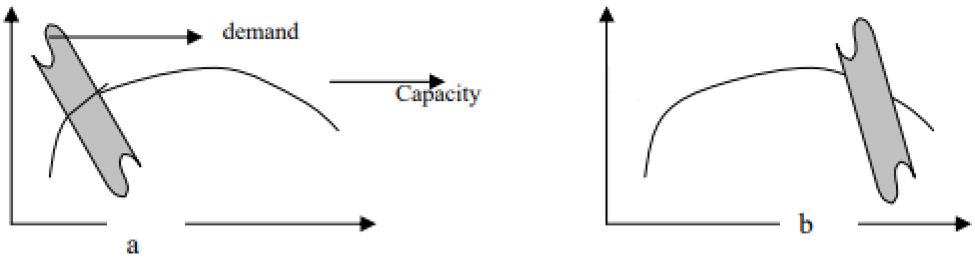

Figure 2: Typical seismic demand versus capacity (a) safe design; (b) unsafe design

III. Performance Analysis

The G+7 conventional building and G+7 Flat slab building are considered in this study. The material Properties are M25 Grade concrete, Fe 500 steel for the yield strength of the longitudinal and transverse reinforcement. The model of flat slab structure and the conventional building are shown in the following figures.

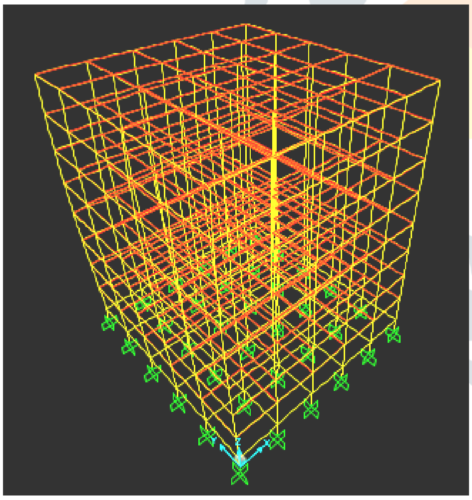

Figure 3: G+7 Conventional RCC structure ETABS model

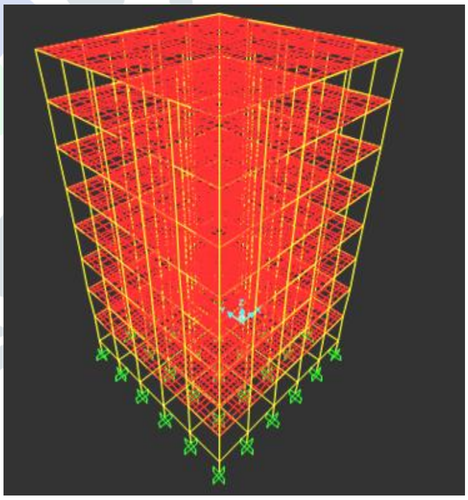

Figure 4: G+7 Flat slab RCC structure ETABS model

The typical floor height is 3 m and the details of beams and columns are shown in table1. A three-dimensional model of each structure has been created to undertake the non-linear analysis.

Table 1: Details of Columns and Beams

Type of Building	Slab (mm)	Column (mm)	Beam (mm)
Conventional Building	120	350 X 350	230 X 380
Flat Slab Building	150	350 X 350	--------

IV. RESULTS AND DISCUSSION

The resulting pushover curve for the conventional building and for flat slab building is shown in fig. No.4.which shows a 2m displacement is given to the structures, the base shear of the conventional structure was 32831.6 KN, and for flat slab structure was 26406.5 KN. Thus the base shear on flat slab is less as compared to the conventional building because the flexibility of flat slab is more than conventional building.

The following figures showing the performance point for flat slab and for conventional building. The performance point for flat slab is 0.437m and for conventional building it is 0.362m thus the performance point for flat slab is more as compare to conventional structure due to they are more flexible than conventional structure.

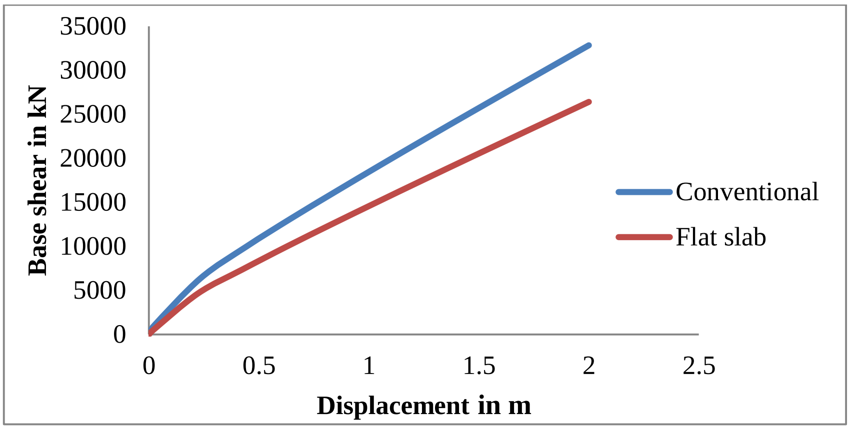

Figure 5 Variation of base shear with respect to displacement in G+ 7 structure

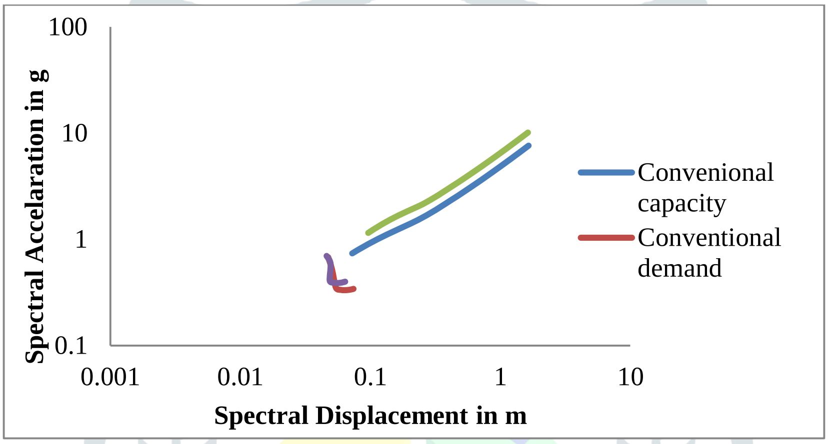

Figure 6 Capacity-Demand curves for Zone IV (G+7 Structure)

V. Conclusion

1. The pushover analysis is a relatively simple way to explore the non linear behaviour of buildings.
2. Base shear of conventional RCC building is more than the flat slab building.
3. The performance point of flat slab is more than the conventional structure due to its flexibility.
4. The behaviour of properly detailed conventional building is adequate as intersection of the demand and capacity curves.
5. The results obtained in terms of demand, capacity gave an insight into real behaviour of the structure.

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